Remarks

Claims 1-50 are pending in the Application.

Claims 2, 7, 14, 19, 31-34, 39, 43 and 47-50 are cancelled without prejudice.

Claims 1, 3-6, 8-13, 15-18 and 20-46 stand rejected.

Claims 1, 11-13, 27, 35-36, 40 and 44 have been amended herein.

Claims 51-67 are added herein

I. RESTRICTION UNDER 35 U.S.C. § 121

Examiner has restricted Claims into three Groups: Claims 1, 3-6, 8-13, 15-18 and 20-46 (Group I), Claims 2, 7, 14, 19 and 50 (Group II) and Claims 47 and 49 (Group III). Office Action, at 2. Applicants confirm their election, with traverse, of Claims 1, 3-6, 8-13, 15-18 and 20-46 belonging to Group I.

II. TERMINAL DISCLAIMER UNDER 37 C.F.R. § 1.321(c)

Examiner has provisionally rejected Claims 1, 3-6, 8-13, 15-18 and 20-46 under the judicially-created doctrine of obvious-type double patenting as being unpatentable over Claims 24-65 of copending Application No. 09/935995. To facilitate prosecution of these claims, Applicant provides, concurrently herewith, a terminal disclaimer under 37 C.F.R. § 1.321.

III. 102(e)/103(a) REJECTIONS OVER *KUPER*

Examiner has rejected Claims 1, 3-6, 8-13, 15-18 and 20-46 under 35 U.S.C. § 102(e) as anticipated by or, in the alternative, under 35 U.S.C. § 103(a) as obvious over Kuper, United States Patent Application Publication No. US 2002/0092613 A1 ("*Kuper*"). Office Action, at 6. Applicant respectfully traverses the rejections.

Applicant respectfully points out that *Kuper* was filed August 23, 2001—the same day that the present Application was filed. As such, *Kuper* is not a valid prior art reference; thus, these rejections are improper and must be withdrawn.

Applicant further notes that *Kuper* claims priority to United States Provisional Patent Application Serial Number 60/227,184, filed on August 23, 2000 (the "*Kuper* Provisional Patent Application," which is attached hereto at Exhibit A). The *Kuper* Provisional Patent Application predates the two provisional patent applications to which Applicant claims priority, namely, United States Provisional Patent Application No. 60/227,604, filed on August 24, 2000, and from United States Provisional Patent Application No. 60/268,269, filed on February 13, 2001 (collectively, the "Applicant Provisional Patent Applications").[1] However, unlike Applicant's Provisional Patent Applications, which do disclose polymer wrapping of nanotubes, no such disclosure is found anywhere in the *Kuper* Provisional Patent Application.

Kuper included the following two sentences, which concluded the first paragraph in the Detailed Description:

> For purposes of this disclosure, "chemical treatment" or "chemically treated" can include functionalization, (covalent attachment of organic functional groups), adherence of a surfactant molecule or wrapping of a polymer around the body of the tube. The sol gel process, as defined in this patent will include a sol of chemically treated SWNTs using the definition of definition of chemical treatment above.

Kuper, pg. 3, para. 27. This is the only mention in *Kuper* respecting surfactants, the adherence of a surfactant molecule to a nanotube, and the wrapping of a polymer around the body of a nanotube. *Id.* In fact, the terms "surfactant" and "wrapping" are not used anywhere else in *Kuper* other than in these two sentences.

A review of the *Kuper* Provisional Patent Application reflects that these two sentences from *Kuper* (quoted above) were new matter added in *Kuper*. (*See Kuper* Provisional Patent Application, at 9 as compared with *Kuper,* pg. 3, para. 27). A further review of the *Kuper* Provisional Patent Application reveals that there is no such disclosure anywhere within.

Accordingly, such new matter is not prior art to the present application. *See* M.P.E.P. § 2136.03(IV).

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[1] Applicant notes that the *Kuper* Provisional Patent Application was filed one day before the first of the two filed Applicant Provisional Patent Applications. As noted *infra*, the *Kuper* Provisional Patent Application is not material to the present Application. Nonetheless, if the Examiner decides to cite the *Kuper* Provisional Patent Application as prior art, Applicant notes that it intends to swear behind this reference. Accordingly, Applicant respectfully asserts that it is not waiving its rights to swear behind this reference and reserves the right to do so at the appropriate time.

The relevance of this is due to the Examiner's specific reliance upon the above quoted language in support of the rejections. Office Action, at 7-8. In fact, this new matter is the cornerstone of the Examiner's arguments that *Kuper* is anticipatory. *Id.*

Accordingly, Applicant respectfully requests that the Examiner withdraw the rejection of Claims 1, 3-6, 8-13, 15-18 and 20-46 under 35 U.S.C. § 102(e) as being anticipated, or in the alternative, under 35 U.S.C. § 103(a) as being obvious over *Kuper.*

IV. 102(e)/103(a) REJECTIONS OVER *BOWER*

Examiner has rejected Claims 24-46 under 35 U.S.C. § 102(e) as anticipated by or, in the alternative, under 35 U.S.C. § 103(a) as obvious over Bower *et al.*, United States Patent No. 6,630,772 ("*Bower*"). Office Action, at 8. Applicant respectfully traverses the rejections.

Regarding rejections under 35 U.S.C. § 102(e), anticipation requires each and every element of the claim to be found within the cited prior art reference. Regarding rejections under 35 U.S.C. § 103(a), to establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art and not based on applicant's disclosure. *See* M.P.E.P. 706.02(j); *see also In re Vaeck,* 947 F.2d 488, 20 U.S.P.Q.2d 1438 (Fed. Cir. 1991).

Regarding Claim 24, this claim requires "a plurality of single-wall carbon nanotubes coated at least in part with a polymer molecule wherein the single-wall carbon nanotubes change dimensionally and electronically in response to chemical adsorption on the surface of the nanotube." *Bower* does not teach or suggest single-wall carbon nanotubes coated at least in part with a polymer molecule wherein the single-wall carbon nanotubes change dimensionally and electronically in response to chemical adsorption on the surface of the nanotube. As *Bower* does not teach or suggest each and every element of this claim, Claim 24 cannot be anticipated by *Bower.* Furthermore, there is no suggestion or motivation in *Bower*, or in the knowledge generally available to one of ordinary

skill in the art, to modify the reference to include such elements. Consequently, a *prima facie* case of obviousness has not been established and, thus, the claim cannot be held obvious under 35 U.S.C. § 103(a).

Regarding Claims 25 and 26, these depend on Claim 24 and cannot be anticipated for the same reasons Claim 24 is not anticipated. Furthermore, Claim 25 requires the element of a chemical sensor. *Bower* does not teach or suggest a chemical sensor. Additionally, Claim 26 requires the element of a transducer. *Bower* does not teach or suggest a transducer. As *Bower* does not teach or suggest each and every element of these claims, and for reasons stated above, Claims 25 and 26 cannot be anticipated by or obvious over *Bower*.

Regarding Claim 27, this claim has been amended for clarity, with the addition of "wherein the aggregates are" coated and requires a "composition of matter comprising aggregates of single-wall carbon nanotubes, wherein the aggregates are coated at least in part with a polymer molecule and wherein the single-wall carbon nanotubes change dimensionally and electronically in response to chemical adsorption on the surface of the nanotubes." As above, *Bower* does not teach or suggest "aggregates of single-wall carbon nanotubes wherein the aggregates are coated at least in part with a polymer molecule wherein the single-wall carbon nanotubes change dimensionally and electronically in response to chemical adsorption on the surface of the carbon nanotubes." As *Bower* does not teach or suggest each and every element of this claim, Claim 27 cannot be anticipated by *Bower*. As there is no suggestion or motivation in *Bower* or in the knowledge generally available to one of ordinary skill in the art to modify the reference to include this element, a *prima facie* case of obviousness has not been established and, thus, the claim cannot be held obvious under 35 U.S.C. § 103(a).

Regarding Claims 28-30, these claims all depend from Claim 27 and are not anticipated by or obvious in view of *Bower* for the same reasons that Claim 27 is not anticipated or obvious.

Regarding Claims 31-34, these claims have been cancelled without prejudice.

Regarding Claim 35, this claim has been amended for clarity to require a "fluid comprising a dispersion of a plurality of single-wall carbon nanotubes coated at least in part with a polymer, whereby the viscosity of the fluid is capable of being controlled by application of a field selected from the group consisting of an electric field, a magnetic field and combinations thereof." *Bower*

does not teach a fluid "whereby the viscosity of the fluid is capable of being controlled by an electric field, a magnetic field or combinations thereof." As *Bower* does not teach or suggest all the elements of the claim, Claim 35 cannot be anticipated by *Bower*. As there is no suggestion or motivation in *Bower*, or in the knowledge generally available to one of ordinary skill in the art, to modify the reference to include this element, a *prima facie* case of obviousness has not been established and, thus, the claim cannot be held obvious under 35 U.S.C. § 103(a).

Regarding Claim 36, this claim has been amended for clarity, to require a "fluid comprising a dispersion of a plurality of aggregates of single-wall carbon nanotubes, wherein the aggregates are coated at least in part with a polymer and whereby the viscosity of the fluid is capable of being controlled by application of a field selected from the group consisting of an electric field, a magnetic field and combinations thereof." *Bower* does not teach or suggest "a dispersion of aggregates of single-wall carbon nanotubes wherein the aggregates are coated at least in part with a polymer," nor a fluid "whereby the viscosity of the fluid is capable of being controlled by the application of a field selected from the group consisting of an electric field, a magnetic field and combination thereof." As *Bower* does not teach or suggest each and every element of this claim, Claim 36 cannot be anticipated by *Bower*. As there is no suggestion or motivation in *Bower* or in the knowledge generally available to one of ordinary skill in the art to modify the reference to include such elements, a *prima facie* case of obviousness has not been established and, thus, the claim cannot be held obvious under 35 U.S.C. § 103(a).

Regarding Claims 37 and 38, these depend on currently amended Claim 36 and cannot be anticipated or obvious for the same reasons Claim 36 is not anticipated or obvious. As *Bower* does not teach or suggest each and every element of these claims, and for reasons stated above, Claims 37 and 38 cannot be anticipated by or obvious over *Bower*.

Regarding Claim 39, this claim has been cancelled without prejudice.

Regarding Claim 40, this claim to a film has been amended for clarity, with the addition of the phrase "wherein the aggregates are" coated and requires a "film comprising a plurality of aggregates of single-wall carbon nanotubes wherein, the aggregates are coated at least in part with a polymer." *Bower* does not teach or suggest "aggregates of single-wall carbon nanotubes wherein the aggregates are coated at least in part with a polymer." Mere melting of polymer in the presence of

nanotubes would not result in "polymer wrapping" around the nanotube aggregates. As *Bower* does not teach or suggest each and every element of this claim, Claim 40 cannot be anticipated by *Bower*. As there is no suggestion or motivation in *Bower* or in the knowledge generally available to one of ordinary skill in the art to modify the reference to include this element, a *prima facie* case of obviousness has not been established and, thus, the claim cannot be held obvious under 35 U.S.C. § 103(a).

Regarding Claims 41 and 42, these depend on newly amended Claim 40 and cannot be anticipated or obvious for the same reasons Claim 40 is not anticipated or obvious. As *Bower* does not teach or suggest each and every element of these claims, and for reasons stated above, Claims 41 and 42 cannot be anticipated by or obvious over *Bower*.

Regarding Claim 43, this claim has been cancelled without prejudice.

Regarding Claim 44, this claim to a fiber has been amended for clarity, with the addition of the phrase "wherein the aggregates are" coated and requires a "fiber comprising a plurality of aggregates of single-wall carbon nanotubes, wherein the aggregates are coated at least in part with a polymer." *Bower* does not teach or suggest a "fiber comprising plurality of aggregates of single-wall carbon nanotubes wherein the aggregates are coated at least in part with a polymer." As *Bower* does not teach or suggest each and every element of this claim, Claim 44 cannot be anticipated by *Bower*. As there is no suggestion or motivation in *Bower* or in the knowledge generally available to one of ordinary skill in the art to modify the reference to include this element, a *prima facie* case of obviousness has not been established and, thus, the claim cannot be held obvious under 35 U.S.C. § 103(a).

Regarding Claims 45 and 46, these depend on newly amended Claim 44 and cannot be anticipated or obvious for the same reasons Claim 44 is not anticipated or obvious. As *Bower* does not teach or suggest each and every element of these claims, and for reasons stated above, Claims 45 and 46 cannot be anticipated by or obvious over *Bower*.

Accordingly, as Applicant has cancelled Claims 31-34, 39 and 43 without prejudice, Applicant respectfully requests that the Examiner withdraw rejection of Claims 24-30, 35-38, 40-42 and 44-46 under 35 U.S.C. § 102(e) as being anticipated, or in the alternative, under 35 U.S.C. § 103(a) as being obvious over *Bower*.

V. 102(e)/103(a) REJECTIONS OVER *DAVEY*

Examiner has rejected Claims 1, 3-6, 8-13, 15-18 and 20-46 under 35 U.S.C. § 102(e) as anticipated by or, in the alternative, under 35 U.S.C. § 103(a) as obvious over Davey et al., United States Patent 6,576,341 ("*Davey*"). Office Action, at 10. Applicant respectfully traverses the rejections.

Regarding Claim 1, this claim requires "a dielectric material" and that the "single-wall carbon nanotubes are substantially electrically-isolated from one another." *Davey* does not teach or suggest a dielectric material or substantial electrical isolation of the nanotubes. As *Davey* does not teach each and every element of this claim, Claim 1 cannot be anticipated *Davey*.

In contrast, *Davey* teaches away from dielectric materials and substantial electrical isolation of the nanotubes with repeated emphasis on using nanotubes to provide electrical conductivity to poor conductors. Numerous references to using carbon nanotubes to enhance electrical conductivity are given throughout *Davey*. For example, "Clearly, the presence of nanotubes enhances the electrical conductivity of what is an intrinsically poor conductor." (*Davey*, col. 6, *ll.* 65-68) Another example, "Other notable benefits are huge increase in conductivity of the order of 10^6 due to the introduction of nanotubes." (*Davey*, col. 7, *ll.* 38-40) Yet another example, "The nanotube polymer composite has electrical conductivity of up to 10^{-3} Sm^{-1} and has application for use in static protection." (*Davey*, at Col 7, *ll.* 46-48) And yet another example, "The method provides a useful polymer nanotube composite material with relatively high electrical conduction which can be blended with other plastics or used as is." (*Davey,* col. 7, *ll.* 59-62). *Davey* must be considered in its entirety (*i.e.*, as a whole), including those portions identified above that lead away from the claimed invention. M.P.E.P. §2141.02; *see also W.L. Gore & Assoc., Inc. v. Garlock, Inc.*, 721 F.2d 1540, 220 U.S.P.Q. 303 (Fed. Cir. 1983).

Accordingly, as there is no suggestion or motivation in *Davey*, or in the knowledge generally available to one of ordinary skill in the art, to modify the reference to include these elements absent from *Davey*, a *prima facie* case of obviousness has not been established and, thus, Claim 1 cannot be held obvious under 35 U.S.C. § 103(a).

Regarding Claims 3-6 and 8-10, all of these claims depend from Claim 1, and are not anticipated or obvious for the same reasons that Claim 1 is not anticipated or obvious.

Regarding Claim 11, this claim has been amended for clarity to require a "dielectric material comprising a plurality of aggregates of single-wall carbon nanotubes, wherein the aggregates are coated at least in part with a polymer molecule and wherein the aggregates of single-wall carbon nanotubes are substantially electrically-isolated from one another." As an initial matter, *Davey* does not disclose, teach, or even suggest aggregates of single-wall carbon nanotubes. Thus Claim 11 is not anticipated or obvious in view of *Davey*.

Furthermore, *Davey* does not teach or suggest a dielectric material, as discussed above. Furthermore, as cited above, *Davey* does not teach or suggest substantial electrical isolation of the nanotubes. As *Davey* does not teach or suggest a dielectric material or the substantial electrical isolation of single-wall carbon nanotubes, Claim 11 cannot be anticipated by *Davey*. In contrast, *Davey* teaches away from dielectric materials and electrical isolation in order for *Davey* to provide electrical conductivity to a media comprising the nanotubes. The same arguments cited for Claim 1 are applied to Claim 11. As there is no suggestion or motivation in *Davey*, or in the knowledge generally available to one of ordinary skill in the art, to modify the reference to include these elements, a *prima facie* case of obviousness has not been established and, thus, the claim cannot be held obvious under 35 U.S.C. § 103(a).

Regarding Claims 12-13, 15-18 and 20-23, these claims all depend directly or indirectly on amended Claim 11 and are not anticipated or obvious for the same reasons that Claim 11 is not anticipated or obvious.

Regarding Claim 24, this claim requires "a plurality of single-wall carbon nanotubes coated at least in part with a polymer molecule wherein the single-wall carbon nanotubes change dimensionally and electronically in response to chemical adsorption on the surface of the nanotube." *Davey* does not teach or suggest "single-wall carbon nanotubes coated at least in part with a polymer molecule wherein the single-wall carbon nanotubes change dimensionally and electronically in response to chemical adsorption on the surface of the nanotube." As *Davey* does not teach or suggest each and every element of this claim, Claim 24 cannot be anticipated by *Davey*. As there is no suggestion or motivation in *Davey* or in the knowledge generally available to one of ordinary skill in

the art to modify the reference to include these elements, a *prima facie* case of obviousness has not been established and, thus, the claim cannot be held obvious under 35 U.S.C. § 103(a).

Regarding Claims 25 and 26, these depend on Claim 24 and cannot be anticipated or obvious for the same reasons Claim 24 is not anticipated or obvious. Furthermore, Claim 25 requires the element of a chemical sensor. *Davey* does not teach or suggest a chemical sensor. Additionally, Claim 26 requires the element of a transducer. *Davey* does not teach or suggest a transducer. As *Davey* does not teach or suggest each and every element of these claims, and for reasons stated above, Claims 25 and 26 cannot be anticipated by, or obvious over, *Davey*.

Regarding Claim 27, this claim has been amended for clarity, with the addition of the phrase "wherein the aggregates are" coated and requires "aggregates of single-wall carbon nanotubes wherein the aggregates are coated at least in part with a polymer molecule and wherein the single-wall carbon nanotubes change dimensionally, electronically, or both in response to chemical adsorption on the surface of the nanotubes." *Davey* does not teach or suggest "aggregates of single-wall carbon nanotubes wherein the aggregates are coated at least in part with a polymer molecule wherein the single-wall carbon nanotubes change dimensionally, electronically, or both in response to chemical adsorption on the surface of the nanotubes". As *Davey* does not teach or suggest each and every element of this claim, Claim 27 cannot be anticipated by *Davey*. As there is no suggestion or motivation in *Davey* or in the knowledge generally available to one of ordinary skill in the art to modify the reference to include these elements, a *prima facie* case of obviousness has not been established and, thus, the claim cannot be held obvious under 35 U.S.C. § 103(a).

Regarding Claims 28-30, these claims depend on currently amended Claim 27 and cannot be anticipated or obvious for the same reasons Claim 27 is not anticipated or obvious. Furthermore, Claim 28 comprises ropes of substantially aligned single-wall carbon nanotubes. *Davey* does not teach or suggest ropes of substantially aligned single-wall carbon nanotubes. Claim 29 requires the element of a chemical sensor. *Davey* does not teach or suggest a chemical sensor. Additionally, Claim 30 requires the element of a transducer. *Davey* does not teach or suggest a transducer. As *Davey* does not teach or suggest each and every element of these claims, and for reasons stated above, Claims 28-30 cannot be anticipated by, or obvious over, *Davey*.

Regarding Claims 31-34, these claims have been cancelled without prejudice.

Regarding Claim 35, this claim has been amended for clarity to require a "fluid comprising a dispersion of a plurality of single-wall carbon nanotubes coated at least in part with a polymer, whereby the viscosity of the fluid is capable of being controlled by application of a field selected from the group consisting of an electric field, a magnetic field and combinations thereof." *Davey* does not teach a fluid "whereby the viscosity of the fluid is capable of being controlled by an electric field, a magnetic field or combinations thereof." As *Davey* does not teach or suggest all the elements of the claim, Claim 35 cannot be anticipated by *Davey*. As there is no suggestion or motivation in *Davey* or in the knowledge generally available to one of ordinary skill in the art to modify the reference to include this requirement, a *prima facie* case of obviousness has not been established and, thus, the claim cannot be held obvious under 35 U.S.C. § 103(a).

Regarding Claim 36, this claim has been amended to for clarity to require "a fluid comprising a dispersion of a plurality of aggregates of single-wall carbon nanotubes wherein the aggregates are coated at least in part with a polymer and whereby the viscosity of the fluid is capable of being controlled by application of a field selected from the group consisting of an electric field, a magnetic field and combinations thereof." *Davey* does not teach or suggest "a fluid comprising a dispersion of aggregates of single-wall carbon nanotubes wherein the aggregates are coated at least in part with a polymer" nor does *Davey* teach that "the viscosity of the fluid is capable of being controlled by application of a field selected from the group consisting of an electric field, a magnetic field and combinations thereof." As *Davey* does not teach or suggest each and every element of this claim, Claim 36 cannot be anticipated by *Davey*. Furthermore, as there is no suggestion or motivation in *Davey* or in the knowledge generally available to one of ordinary skill in the art to modify the reference to include this requirement, a *prima facie* case of obviousness has not been established and, thus, the claim cannot be held obvious under 35 U.S.C. § 103(a).

Regarding Claims 37 and 38, these depend on newly amended Claim 36 and cannot be anticipated or obvious for the same reasons Claim 36 is not anticipated or obvious. As *Davey* does not teach or suggest each and every element of these claims, and for reasons stated above, Claims 37 and 38 cannot be anticipated by or obvious under *Davey*.

Regarding Claim 39, this claim has been cancelled without prejudice.

Regarding Claim 40, this claim to a film has been amended for clarity, with the addition of

the phrase "wherein the aggregates are" coated and requires "a film comprising a plurality of aggregates of single-wall carbon nanotubes wherein the aggregates are coated at least in part with a polymer." *Davey* does not teach or suggest "a film comprising a plurality of aggregates of single-wall carbon nanotubes wherein the aggregates are coated at least in part with a polymer." As *Davey* does not teach or suggest each and every element of this claim, Claim 40 cannot be anticipated by *Davey*. As there is no suggestion or motivation in *Davey* or in the knowledge generally available to one of ordinary skill in the art to modify the reference to include this element, a *prima facie* case of obviousness has not been established and, thus, the claim cannot be held obvious under 35 U.S.C. § 103(a).

Regarding Claims 41 and 42, these depend on newly amended Claim 40 and cannot be anticipated or obvious for the same reasons Claim 40 is not anticipated or obvious. As *Davey* does not teach or suggest each and every element of these claims, and for reasons stated above, Claims 41 and 42 cannot be anticipated by or obvious over *Davey*.

Regarding Claim 43, this claim has been cancelled without prejudice.

Regarding Claim 44, this claim to a fiber has been amended for clarity, with the addition of the phrase "wherein the aggregates are" coated and requires "aggregates of single-wall carbon nanotubes wherein the aggregates are coated at least in part with a polymer." *Davey* does not teach or suggest "a fiber comprising a plurality of aggregates of single-wall carbon nanotubes wherein the aggregates are coated at least in part with a polymer." As *Davey* does not teach or suggest each and every element of this claim, Claim 44 cannot be anticipated by *Davey*. As there is no suggestion or motivation in *Davey* or in the knowledge generally available to one of ordinary skill in the art to modify the reference to include this element, a *prima facie* case of obviousness has not been established and, thus, the claim cannot be held obvious under 35 U.S.C. § 103(a).

Regarding Claims 45 and 46, these depend on currently amended Claim 44 and cannot be anticipated or obvious for the same reasons Claim 44 is not anticipated or obvious. Claims 45 and 46 further require substantially aligned single-wall carbon nanotubes. *Davey* does not teach substantially aligned single-wall carbon nanotubes. As *Davey* does not teach or suggest each and every element of these claims, and for reasons stated above, Claims 45 and 46 cannot be anticipated by or obvious over *Davey*.

Accordingly, as Applicant has cancelled Claims 31-34, 39 and 43 without prejudice, Applicant respectfully requests that the Examiner withdraw rejection of Claims 1, 3-6, 8-13, 15-18, 20-30, 35-38, 40-42 and 44-46 under 35 U.S.C. § 102(e) as being anticipated, or in the alternative, under 35 U.S.C. § 103(a) as being obvious over *Davey*.

VI. ADDED CLAIMS

New Claims 51-67 have been added and are directed to compositions comprising single-wall carbon nanotubes in which the compositions change dimensionally, electronically, or both in response to "an applied electric field ", an "applied magnetic field", and "chemical adsorption on the surface of the nanotube". No new matter is added by way of these claims. Support for these claims is found, for example, in the Application, at page 9, *ll.* 8-13.

V. CONCLUSION

As a result of the foregoing, it is asserted by Applicant that the Claims in the Application are now in a condition for allowance, and respectfully request an early allowance of such Claims.

Applicant respectfully requests that the Examiner call Applicant's attorney at the below listed number if the Examiner believes that such a discussion would be helpful in resolving any remaining problems.

Respectfully submitted,

WINSTEAD SECHREST & MINICK P.C.

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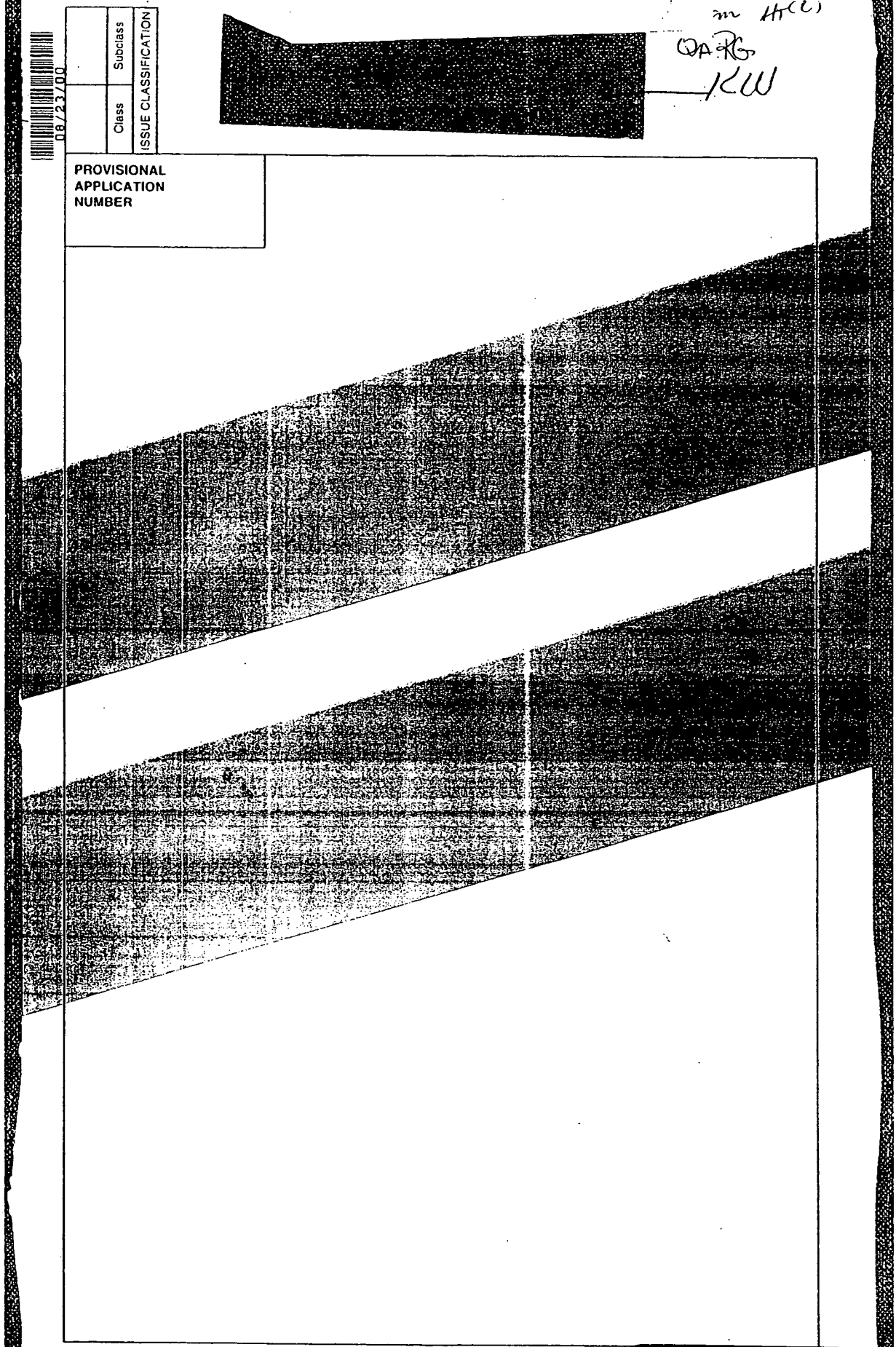

08/23/00

Class	Subclass
ISSUE CLASSIFICATION	

PROVISIONAL APPLICATION NUMBER

Form PTO-1625
(Rev. 6/99)

(FACE)

EXHIBIT A

PATENT APPL ATION

60227184

Date Entered or Counted

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Application

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Bib Data Sheet

SERIAL NUMBER	FILING DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
60/227,184	08/23/2000 RULE _	–	–	65304-001

APPLICANTS

Cynthia A. Kuper, Philadelphia, PA ;

** CONTINUING DATA **********

** FOREIGN APPLICATIONS **********

** SMALL ENTITY **

Foreign Priority claimed	STATE OR COUNTRY	SHEETS DRAWING	TOTAL CLAIMS	INDEPENDENT CLAIMS
☐ yes ☐ no	PA	2	–	–
35 USC 119 (a-d) conditions met ☐ yes ☐ no ☐ Met after Allowance				
Verified and Acknowledged Examiner's Signature Initials				

ADDRESS

25203

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TITLE

Method for utilizing sol-gel processing in the production of a macroscopic two or three dimensionally ordered array of single wall nanotubes (SWNTS)

FILING FEE RECEIVED	FEES: Authority has been given in Paper	
100	No. _____ to charge/credit DEPOSIT ACCOUNT No. _____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53 (c).

INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
Cynthia A.	Kuper	1520 Spruce Street Apartment 703 Philadelphia, PA 19103

[ ] *Additional inventors are being named on the ___ separately numbered sheets attached hereto*

TITLE OF THE INVENTION (280 characters max)

Method for Utilizing Sol-Gel Processing in the Production of a Macroscopic Two or Three Dimensionally Ordered Array of Single Wall Nanotubes (SWNTS)

Direct all correspondence to: **CORRESPONDENCE ADDRESS**

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ENCLOSED APPLICATION PARTS *(check all that apply)*

[X] Specification *Number of Pages* 13 [ ] Small Entity Statement

[X] Drawing(s) *Number of Sheets* 2 [ ] Other (specify)

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT *(check one)*

[ ] A check or money order is enclosed to cover the filing fees

[ ] The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number: ____

FILING FEE AMOUNT ($)

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

[ ] No.

[ ] Yes, the name of the U.S. Government agency and the Government contract number are: ____

Respectfully submitted,

SIGNATURE [signature] Date 8/23/00

TYPED or PRINTED NAME Scott J. Fields REGISTRATION NO. *(if appropriate)* 32,857

TELEPHONE 215-665-3214 Docket Number: 65304-001

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

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JC902 U.S. PTO 08/23/00

jc714 U.S. PTO 60/227184 08/23/00

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DOCKET NO. 65304-001

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re: Provisional Patent Application

Title: Method for Utilizing Sol-Gel Processing in the Production of a Macroscopic Two or Three Dimensionally Ordered Array of Single Wall nanotubes (SWNTs)

Inventor: Cynthia A. Kuper

CERTIFICATE OF EXPRESS MAIL UNDER 37 CFR 1.10

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Date of Deposit: August 23, 2000

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SCOTT J. FIELDS

Date: August 23, 2000

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Title

Method for utilizing sol-gel processing in the production of a macroscopic two or three dimensionally ordered array of single wall nanotubes (SWNTs).

Field of the Invention

The Invention relates to the field of materials science and materials fabrication comprising carbon nanotubes.

Background of the Invention

Carbon is a critical element of organic material, which makes up all living matter. Matter composed solely of carbon exists in the form of graphite, diamond and most recently the fullerenes. These forms are called allotropes and are chemically very stable. Allotropes of carbon can be used alone, or in combination with other materials to form composites, to make applicable materials such as industrial diamonds; for cutting tools and flat panel displays, carbon filaments; in the form of fibers for structural reinforcement and dielectrics, activated carbon; for filtration devices, electrode materials for the manufacturer of steel, construction materials; for insulation of nuclear reactors, and graphite rods; for high-temperature hearing elements.

With the discovery of the third allotrope of carbon, the fullerenes, carbon materials having a fine tubular structure within the order of a nanometer in diameter, have been discovered on a carbon rod after an arc discharge, a common way of producing carbon fullerenes (S. Iijima, Nature, Vol. 354, pp. 56-58, 7 Nov. 1991). These fibrilar carbon materials may be visualized by (a) providing benzene shell-like hexagonal molecules as a constituent unit which are formed by covalent bonding of carbon atoms,

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(b) placing the molecules tightly in a plane to form a carbon molecule sheet, (c) rolling the carbon molecule sheet into a cylindrical shape to form a cylindrical carbon tube as a unit or a high-molecular building block, (d) repeating the above steps (a)-(c) to form a plurality of cylindrical carbon tubes having different diameters, and thereafter (e) arranging their cylindrical carbon tubes in a concentric configuration to form a telescopic structure.

The above-mentioned cylindrical tubes have an extreme micro-diameter of the order of 1 nm at a minimum, and the spacing between a cylindrical tube and its inside cylindrical tube or its outside cylindrical tube is of the order of 0.34 nm which is approximately the same as the interlayer spacing of a graphite molecule. The interaction between tubes is van der Waals type, and electron transfer from tube to tube is very small. In the above-mentioned telescopic structure, there are various kinds of structure such as a double structure, triple structure, quadruple structure, quintuple structure.

The above fibrilar carbon material will be hereinafter referred to in some cases as a "(carbon) nanotube" or a "(carbon) tube". Carbon nanotubes can take an almost infinite number of structures, which are characterized both by their diameter and their degree of helicity. The relation between the molecular structure and electronic band structure of the carbon nanotube has been taught in Japanese Patent Application No. 56306/1992 which was laid open on Sep. 7, 1993 under Japanese Unexamined Patent Publication No. 229809/1993, the disclosure of which is hereby incorporated by reference herein. In addition, a method of fabricating carbon tube devices having desired properties on the basis of the above relation has been proposed therein.

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The above Application No. 56306/1992 and N. Hamada et al., Phys. Rev. Lett., 68(10), pp.1579-1581(1992) teach that the carbon nanotubes exhibit a variety of properties in electronic conduction from a metal to a semiconductor having various band gaps, depending on the radius of the cylindrical tube and the degree of helical arrangement of the six-membered carbon rings (i.e. the carbon hexagons), further, that the carbon nanotubes are useful as a material for use in functional devices utilizing such properties.

On the other hand, soccer ball-like spherical high-molecular weight carbon materials having benzene shell-like hexagonal molecules as a constituent unit or molecular building block are taught in S. Iijima et al., Nature, Vol. 356, pp. 776-778(1992). S. Iijima et al. have shown that a variety of complex variants of carbon nanotubes are obtained by introducing pentagons and heptagons into the hexagonal network. Also, it is known that the molecules such as C.60, C.70, C.78, C.82, can exist in a stable state. These soccer ball-like spherical carbon materials are in the solid state or in the form of a face-centered cubic lattice or any other crystal structures depending on van der Waals forces. If the crystal or solid material is doped with K, Rb, Cs or the like, the doped material exhibits the metal conduction and superconductivity at low temperature.

The above-mentioned carbon nanotube and soccer ball-like materials and high-molecular weight materials derived from either of them are thus well known. Carbon nanotubules have received a great attention as a new base material applicable to various industries. The teachings of U.S. Patent No. 5,457,343, for example, discloses the use of a carbon nanotubule as an absorbent or complex enclosure for foreign materials.

Graphite is a layered material and is structured with the carbon hexagons spread out two dimensionally and repeated forming layers of graphite sheets. The methods of making graphite carbon materials have been well established and are being used by industry for mass production of graphite. The methods of making normal graphite materials are divided into three main types. There is a method of forming graphite using a liquid-phase carbonization process with ground coke and a bonding material as raw materials. There is a method which uses a solid-phase carbonization process using spun polyacrylonitrile, pitch and rayon filaments as they are, and there is a method which thermally decomposes hydrocarbon gases and then performs a gas-phase carbonization process.

Of the carbon materials with graphite type structure, graphite filaments could have been obtained by using the solid-phase carbonization method mentioned above, or could have been formed by thermal decomposition of hydrocarbon gases using metallic granules as a catalyst, or could have been obtained by forming amorphous carbon filaments using metallic granules as a catalyst and then heat-treating these filaments to make graphite. Also, a method is known of where needle shaped graphite could have been grown by applying a direct current discharge between two graphite electrodes in a rare gas atmosphere.

For example, one of the prior methods of growing the graphite filaments was proposed in 1960 by Roger Bacon of Union Carbide Co. (U.S.A.) (J. Appl. Phys., Vol. 31, p. 283 (1960)), and in this method direct current is discharged between two carbon-rod electrodes in an argon gas atmosphere at approximately 90 atmospheres, forming graphite filaments with a diameter of 1 to 5 .mu.m and length of 2 to 3 cm on the

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negative electrode. Using this method, the crystal structure of the resulting graphite filament is the same as that of normal graphite. In other words, each of the graphite filaments is structured with several oblong shaped single crystal graphite bundled around the filament axis, and each oblong graphite crystals bond together along the crystal boundaries to form a polycrystalline structure.

As mentioned above, the chemical and physical properties of carbon materials taking currently known graphitic structures as the main structural unit are well known. When considering more diverse industrial applications of carbon, a new carbon carbon-based material having a new structure is desired.

Carbon nanotubes have been refined so that they can be can be synthesized as single wall nanotubes (SWNTs.) SWNTs are micron long nanometer diameter tubes composed solely of carbon atoms. The geometrical arrangement of the carbon atoms in a SWNT is that of graphene (a single sheet of graphite). The overall configuration resembles a sheet of chicken wire, which is rolled to close seamlessly and capped with hemispheres on each end of the tube. In each vertice of the hypothetical chicken wire exists a carbon atom. This provides the graphene configuration. SWNTs are proposed to be 100 times stronger than steel at 1/6 the weight. SWNTs have the highest strength to weight ratio of any material known today. They can have conductivities of a metal or a small gap semiconductor, parallel to the tube axis. Perpendicular to the tube axis they are completely insulating and have thermal properties similar to diamond. These remarkable properties are entirely anisotropic and therefore rely on the SWNTs to be completely aligned with respect to one another.

While carbon nanotubes and SWNTs have been known, there has heretofore been no known way to produce an ordered array of SWNTs. The term "ordered array" defines a periodic architecture composed of SWNTs aligned with respect to one another in either a parallel or perpendicular configuration. Such a parallel configuration would have all the tubes aligned along the tube axis and would be considered a two dimensional array. A perpendicular configuration would have an alternating structure of every other tube aligned parallel to the tube axis with tubes in between lying perpendicular and would be considered a three dimensional array. These architectures would allow for the full exploitation of all the properties, electrical and mechanical, of a SWNT in bulk.

Such macroscopically aligned arrays of SWNTs produced via this methodology have applications towards structural reinforcement materials such as those in automobile panels, airplane fuselage structures, as well as maritime and aerospace technologies. Applications also include those for biotechnology such as use in synthetic membranes and skins. Fiber processing of SWNTs can also be achieved using this method.

The sol gel process is a known chemical protocol that involves initially a sol, a sub micron solid particle forming a colloidal suspension in a liquid, Secondly, an additive which gels the sol, usually a chemical that promotes condensation of more than one solid particle to itself, Thirdly: a heat treatment period which evaporates the liquid. The final result is a thin (<1um) or thick film (>1um) of a dimensionally ordered solid array.

Sol gel processing as described above is principally used in the ceramic industry. It is a well known and reliable method for making high temperature ceramic composites and ceramic films. It is a significant technique in that it allows one to process solid particles using wet chemistry. This lends control and precision in the development of the

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final product. Insoluble particles are traditionally hard to process. Sol gel processing provides a powerful solution to these processing limits.

The use of sol gel processing, heretofore, has not been applied to SWNTs. SWNTs are not soluble in any liquid and this causes the material to have many processing limits. Sol Gel processing of SWNTs will over come these barriers and allow the material to be used for the many applications previously mentioned.

It is the fundamental purpose of the present invention to provide a method for fabricating two or three dimensionally order arrays of SWNTs using sol gel processing.

Summary of the Invention

In accordance with the present invention, a method for fabricating of macroscopic two or three dimensionally ordered arrays of single wall nanotubes (SWNTs) is disclosed. The first embodiment of the invention comprises the following steps: chemically treating purified SWNTs using known laboratory protocols, comprised of standard organic chemistry techniques, to add chemically reactive groups (functional groups) to either the tube ends or tube bodies in order to functionalize the SWNTs; applying the sol-gel process to these functionalized carbon nanotubes, which is comprised of the following steps; suspending the functionalized SWNTs in an appropriate liquid medium such that a colloid is produced; treating the colloid with a chemical or heat to promote coupling of the individual functionalized SWNTs to each other; and heating the coupled SWNTs to evaporate any excess liquid so as to provide a final product comprising an array of covalently bound functionalized SWNTs.

The second embodiment of the invention comprises a method for fabricating of macroscopic two or three dimensionally ordered arrays of single wall nanotubes

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(SWNTs) comprising the following steps: chemically treating purified SWNTs using known laboratory protocols, comprised of standard organic chemistry techniques, to add chemically reactive groups comprising alcohols or amines to either the tube ends or tube bodies in order to functionalize the SWNTs; applying the sol-gel process to these functionalized carbon nanotubes, which is comprised of the following steps; suspending the functionalized SWNTs in an appropriate liquid medium such that a colloid is produced; treating the colloid with a chemical or heat to promote the covalent bonding of the individual functionalized SWNTs to each other; and heating the coupled SWNTs to evaporate any excess liquid so as to provide a final product comprising an array of covalently bound functionalized SWNTs.

The third embodiment of the invention comprises the steps in the first and/or second embodiment of the invention coupled with the use of shear stress (a uniaxial applied load) on the "gel"; the stage of sol-gel processing prior to evaporation of the entirety of the liquid, electric fields, and/or magnetic fields to further promote alignment of the carbon nanotubes in the gel stage.

The fourth embodiment of the invention is the inclusion of the first, second and/or third embodiments coupled with the addition of a second substance to the sol-gel processing. This substance can be a polymer, epoxy, resin or ceramic material such that introduction of a colloidal suspension of the second substance to the colloidal suspension of the functionalized carbon nanotubes, with subsequent sol-gel processing on the mixture, yield a composite system. This composite system may have both components substantially aligned with respect to one another in a two or three dimensional fashion.

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Description of the Figures

Figure 1 is a flow diagram of the method of the present invention.

Detailed Description of the Invention

The present invention and method is now described as follows with reference to the attached flow diagram. In a most preferred embodiment, the present invention is directed to a method for using sol gel processing in the production of a macroscopic two or three dimensionally ordered array of carbon nanotubes, either of the multiwall or single wall variety. First, the purified carbon nanotubes are chemically treated using known laboratory protocols, comprised of standard organic chemistry techniques, to add chemically reactive groups to the tube ends and/or tubes body. The reactive groups may be, but are not limited to, primary alcohols and amines. This synthesis is performed using known methods for side wall (tube body) functionalization of the carbon nanotubes and may include further modifications to the synthesis.

The functionalized carbon nanotubes (carbon nanotubes with chemical groups attached) are then suspended in an appropriate liquid medium such that a colloid is produced, i.e., a stable suspension of individual functionalized SWNTs. This colloid will be treated with the addition of another chemical or by physical means such as heat to promote condensation or other chemically driven coupling of the individual solid particles (functionalized SWNTs) to each other.

The final step in the processing drives off any excess liquid by heating to leave the final product consisting of an array of functionalized SWNTs covalently bound to another.

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SWNTs fabricated according to the present invention will have a number of applications including filtration devices for water purification and physical separation, reinforced fibers and films for military applications, conductive films and paints, composites for automobile panel and airplane fuselages, membranes for batteries, hydrogen storage and biotechnology, and three dimensional composites.

The parameters of the sol gel processing may be modified to control the dimensionality and ordering in the final array. These parameters are defined as the gellation point, heat treatment temperature, concentration, degree, type and space arrangement of the functional groups on the SWNTs.

The present invention has been described with reference to the above detailed description. The true nature and scope of the present invention is to be construed with reference to the claims appended hereto.

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Claims

1. A method for fabricating of macroscopic two or three dimensionally ordered arrays of single wall nanotubes (SWNTs) comprising the following steps:

chemically treating purified SWNTs using known laboratory protocols, comprised of standard organic chemistry techniques, to add chemically reactive groups to either the tube ends or tube bodies in order to functionalize the SWNTs;

suspending the functionalized SWNTs in an appropriate liquid medium such that a colloid is produced;

treating the colloid with a chemical or heat to promote coupling of the individual functionalized SWNTs to each other; and

heating the coupled SWNTs to evaporate any excess liquid so as to provide a final product comprising an array of covalently bound functionalized SWNTs.

2. A method for fabricating of macroscopic two or three dimensionally ordered arrays of single wall nanotubes (SWNTs) comprising the following steps:

chemically treating purified SWNTs using the sol gel process to add chemically reactive groups comprising alcohols or amines to either the tube ends or tube bodies in order to functionalize the SWNTs;

suspending the functionalized SWNTs in an appropriate liquid medium such that a colloid is produced;

treating the colloid with a chemical or heat to promote the covalent bonding of the individual functionalized SWNTs to each other; and

heating the coupled SWNTs to evaporate any excess liquid so as to provide a final product comprising an array of covalently bound functionalized SWNTs.

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3. Performing all of the steps in claim 1 and/or 2 with addition of another substance; a polymer, epoxy, resin or ceramic material, such that the second material is added in a stable colloidal form to the colloid of carbon nanotubes, and after the steps comprising claim 1 and/or 2 are performed, a composite material is formed which consists of a two or three dimensionally ordered system consisting of carbon nanotubes and a polymer, epoxy, resin or ceramic material.

4. Utilization of a shear stress, electric and/or magnetic field on the gel produced by condensing either carbon nanotubes to themselves or carbon nanotubes to a polymer, epoxy, resin or ceramic material, such that alignment is promoted in the gel.

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Abstract

A method for fabricating of macroscopic two or three dimensionally ordered arrays of single wall nanotubes (SWNTs) comprising the following steps: chemically treating purified SWNTs using the sol gel process to add chemically reactive groups to either the tube ends or tube bodies in order to functionalize the SWNTs; suspending the functionalized SWNTs in an appropriate liquid medium such that a colloid is produced; treating the colloid with a chemical or heat to promote coupling of the individual functionalized SWNTs to each other; and heating the coupled SWNTs to evaporate any excess liquid so as to provide a final product comprising an array of covalently bound functionalized SWNTs.

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Figures:

Synthesis flow chart

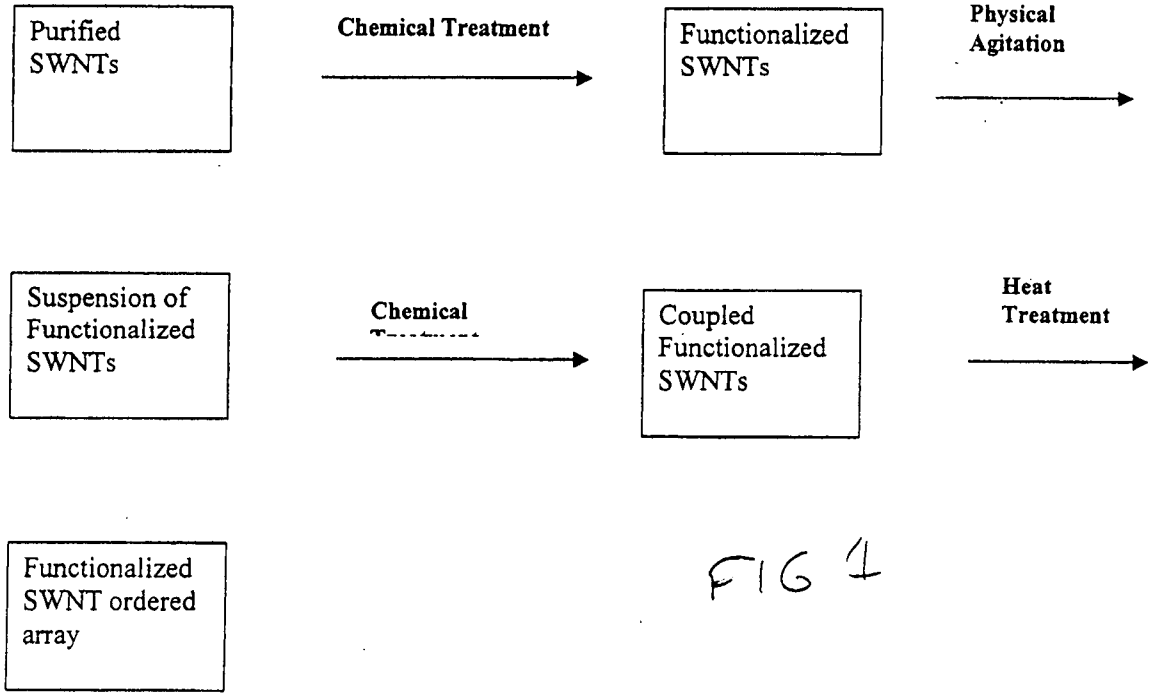

FIG 1

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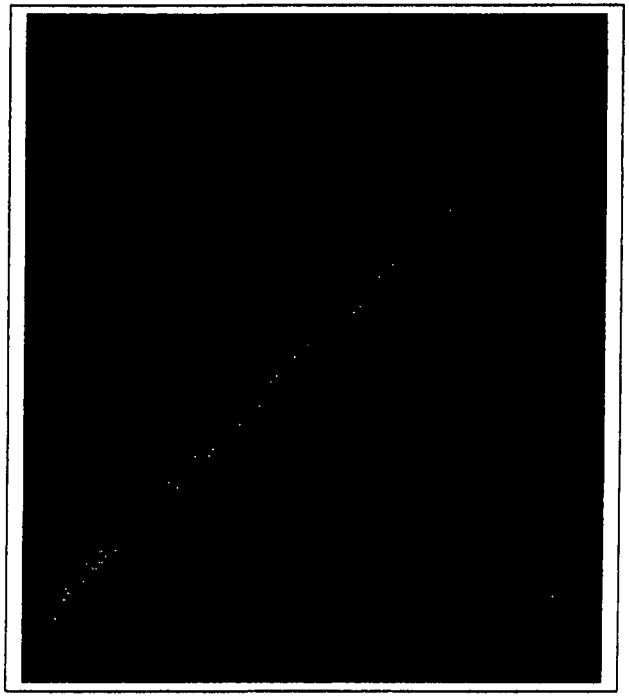
Computational Model of a SWNT, Daniel Colbert, Rice University



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APPLICATION NUMBER	FILING/RECEIPT DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NUMBER
60/227,184	08/23/2000	Cynthia A. Kuper	65304-001

25203
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Provisional Patent Application of

Cynthia A. Kuper

Application No: 60/227,184

Filing Date: August 23, 2999

For: Method for utilizing sol-gel processing in the production of a macroscopic two or three dimensionally ordered array of single wall nanotubes (SWNTs)

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Respectfully submitted,

SCOTT J. FIELDS
Registration No. 32,857

Date: November 27, 2000

DOCKET NO.: 65304-001

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Provisional Patent Application of

Cynthia A. Kuper

Application No: 60/227,184

For: Method for utilizing sol-gel processing in the production of a macroscopic two or three dimensionally ordered array of single wall nanotubes (SWNTs)

Filing Date: August 23, 2000

SMALL ENTITY STATUS STATEMENT

Individual Inventor Cynthia A. Kuper claims small entity status.

Respectfully submitted,

SCOTT J. FIELDS
Registration No: 32,857

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APPLICATION NUMBER	FILING/RECEIPT DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NUMBER
60/227,184	08/23/2000	Cynthia A. Kuper	65304-001

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